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Forecasting Intensity and Direction of Tropical Cyclones and Investigating their Impacts on Renewable Energy Power Plants in Iran

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General Note



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ABSTRACT

As one of the biggest vectors on ocean's surface, winds influence a great range of ocean's surface from little waves to great streams. Winds also balance interactions between atmosphere and ocean by stabilizing heat, moisture and gases with ocean's air. In addition, oceanic vector winds can cause devastating forces which are called tropical cyclones. These forces can cause life and property damage. Therefore, it is important to forecast it. It also has a great importance in operation of renewable energy power plants. In this paper, the intensity and direction of tropical cyclones are forecasted and their impacts are analyzed using Matlab software.

Keywords: Dual-Frequency Scatterometer, forecasting, oceanic vector winds, renewable energy, tropical cyclones.

1. INTRODUCTION

Over 70% of Earth's surface comprises from ocean, which makes satellite remote sensing a logical and significant component of an overall effort to meet societal needs for weather and water information; support commerce with information for safe, efficient, and environmentally sound transportation; and provide information for better coastal preparedness. Ocean surface vector winds (OSVW) are crucial pieces of information needed to understand and predict the short-term and longer term processes that drive our planet's environment. As the largest source of momentum for the ocean surface, winds affect the full range of ocean movement, from individual surface waves to complete current systems. Winds along the ocean surface regulate interaction between the atmosphere and the ocean via modulation of air-sea exchanges of heat, moisture, gases, and particulates. With the ocean covering almost three quarters of Earth's surface, this interaction has significant influence on global and regional climate.

Each year hurricanes, typhoons, and other tropical cyclones cause thousands of fatalities and tens of billions of dollars of economic losses throughout the world. Severe examples include the tropical cyclone that killed more than 300,000 people in Bangladesh in 1970, and in the United States: the Galveston Hurricane of 1900, which destroyed the city and killed between 6000 and 8000 people; Hurricane Andrew, which caused monetary losses of 26.5 billion dollars (normalized to 38 billion dollars by inflation, wealth and population changes) in 1992; and, most recently, Hurricane Katrina, which killed more than 1300 people and resulted in losses in excess of 100 billion dollars. Even storms of much lesser intensity can produce significant loss of life and property, presenting a daunting challenge for hurricane forecasters and the communities they serve.

Although individual years may vary, the number of hurricanes and the number of major hurricanes (defined as Category 3 or higher on the Saffir-Simpson scale) has been increasing in recent years. The year 2004 was a very active season for the North Atlantic with 15 named storms, nine of which became hurricanes, and six of which became major hurricanes. These included Hurricanes Charlie, Frances, Ivan and Jeanne, which all caused extensive damage and loss of life. The year 2005 continued this upward trend, with 28 named storms, 15 hurricanes, three Category 5 hurricanes, and four major hurricanes hitting the United States.

2. SCATTEROMETRY

The technique of radar scatterometry is summarized in detail by CF05. Briefly, wind speed and direction are obtained by combining measurements of radar backscatter from a given location on the sea surface at multiple antenna look angles. For QuikSCAT, these multiple viewing angles are facilitated by the movement of the satellite along its orbit that provides forward and aft views from four different measurement geometries within a time interval of 4.5 min. The accuracy of the wind retrievals is best characterized in terms of vector component errors (Freilich and Dunbar 1999); the QuikSCAT accuracy is about 0.75 m s^{-1} in the along wind component and about 1.5 m s^{-1} in the crosswind component (CF05). Wind direction accuracy is thus a sensitive function of wind speed at low wind speeds but improves rapidly with increasing wind speed. At wind speeds higher than about 6 m s^{-1} , the QuikSCAT directional accuracy is about 14° . In general, the accuracies of QuikSCAT wind retrievals are degraded when rain significantly contaminates the radar footprint. When the wind speed is sufficiently strong, however, accurate winds can often be retrieved even in raining conditions. Scatterometry provides far more extensive geographical and temporal coverage and higher spatial resolution of ocean vector winds than are obtained by any other means. In the standard processing of the QuikSCAT data, the radar backscatter measurements are binned in 25-km areas for vector wind retrievals (see Fig. 4 of CF05). The high resolution of scatterometer wind observations can be quantified from along track wavenumber spectral analysis (e.g., Freilich and Chelton 1986; Wikle et al. 1999; Milliff et al. 1999, 2004; Patoux and Brown 2001). The heavy solid lines in Fig. 1 are the wavenumber spectra of the QuikSCAT zonal and meridional wind components and the wind speed in the eastern North Pacific. In all three variables, the dependence on wavenumber k drops off as approximately k^{-2} at low wavenumbers. The wavenumber rolloff is somewhat flatter at wavelengths shorter than about 1000 km (i.e., wavenumbers higher than about 10^{-3} cycles per kilometer).

3. DUAL-FREQUENCY SCATTEROMETER (DFS) DESIGN

The DFS designed by JPL for the GCOM-W2 satellite is a scanning pencil-beam scatterometer with a 360° field of view similar to QuikSCAT. The two incidence angles will be slightly different than those of QuikSCAT to preserve the 1800-km wide swath at the 700-km altitude of GCOM-W. Additional DFS details are:

- Ku-band real-aperture radar operating at 13.4-GHz frequency at two polarizations (V and H) and two incidence angles.
- C-band real aperture type radar operating at 5.4-GHz frequency at H-polarization and two incidence angles.
- A solid graphite composite reflector antenna size which was 2 m in the original DFS design (and was used in the simulations presented here), but may ultimately have to be reduced to 1.8 m.

The characteristics of DFS instrument design and measurement geometry are compared with QuikSCAT and XOVWM instruments in Fig. 1 and 2.

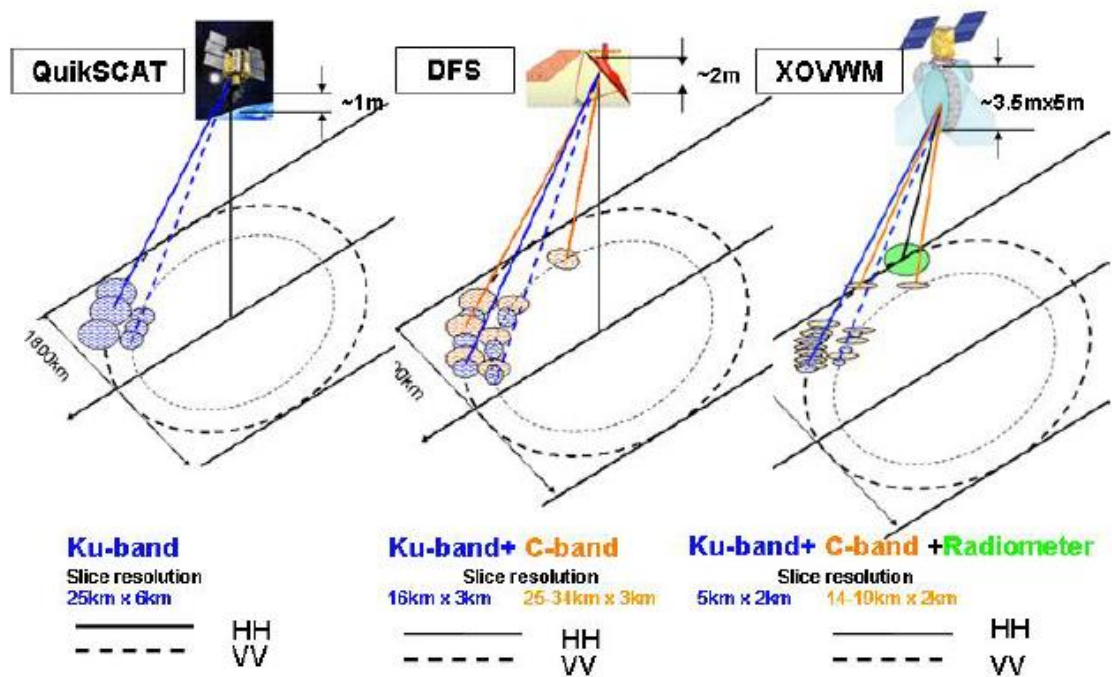


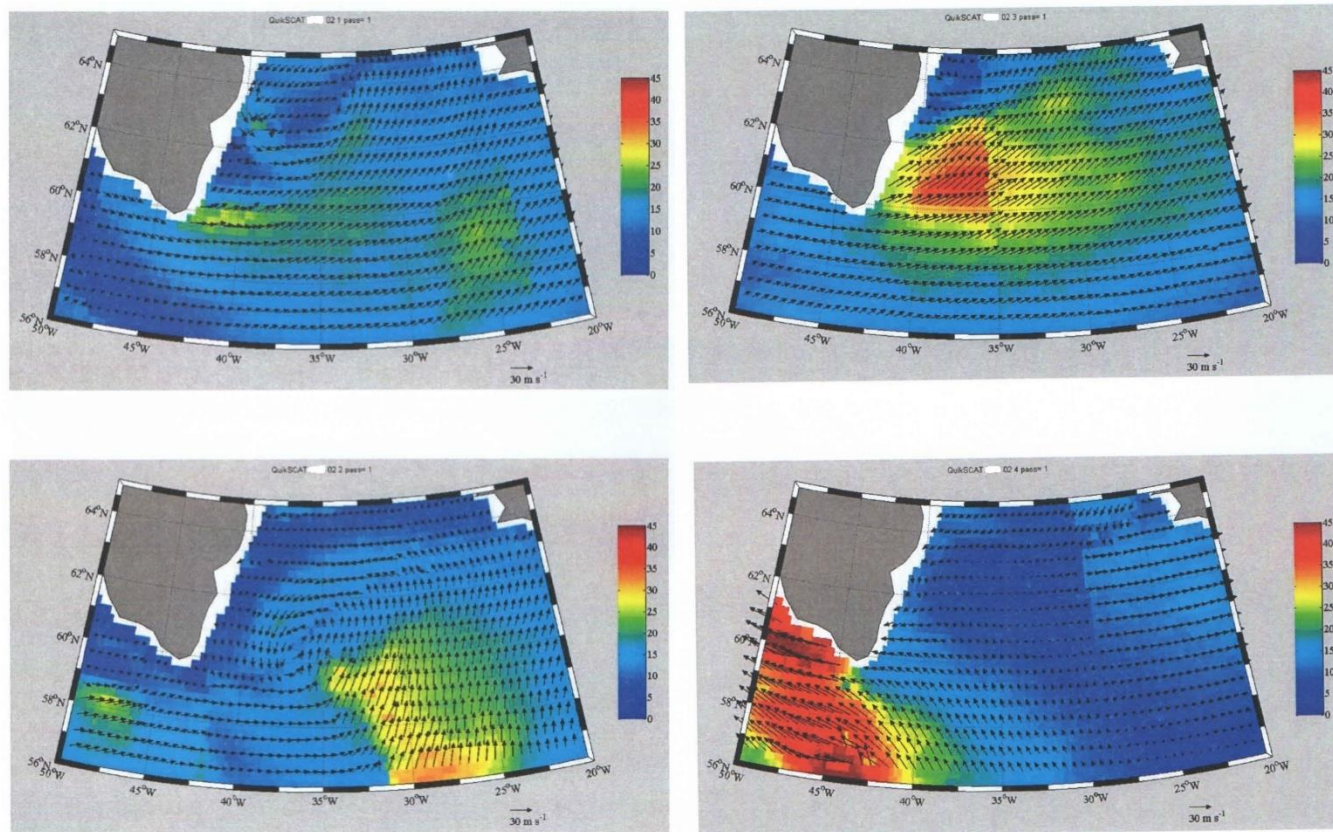
Figure 1 Measurement geometry of QuikSCAT, DFS and XOVWM instruments

Table 1 Minimum requirement of DFS sampling and operation

WVC Size	10 km
Coverage	90% of the ocean surface every 24 h
Wind Speed Accuracy (RMS)	3-20 m/s: 2m/s
	20-30 m/s: 10%
	30-50 m/s: 10%
	50-80 m/s: 20%
Wind Direction Accuracy (RMS)	3-30 m/s: 20°
	30-50 m/s: 20°
	50-80 m/s: 30°
Retrieval in Precipitation	Near all-weather wind retrieval
Product Latency	< 180 min for 85% of the data

4. SIMULATION RESULTS

After simulating wind vectors from QuikSCAT data for some days of February 2015, results are as follow:



5. CONCLUSION

In this paper, the impact of tropical cyclones on renewable energy power plants are presented. For this purpose, data of weather for a limited time is acquired by QuikSCAT and simulated using mfile part of MATLAB software. Using this software, and identifying assumed date, it is possible to draw characteristics of oceanic vector winds of Scattometer. Acquired algorithm as follow: First, studies associated with this subject is carried out. Afterward, using Matlab software, input data is inserted and simulation is carried out using mfile part of Matlab. The purpose of simulation was predicting short term impact of tropical cyclones on renewable energy power plant. This prediction is finally drew and illustrated in figures.

REFERENCES

1. R. Atlas, A. Y. Hou, O. Reale, "Application of Sea Winds scatterometer and TMI- SSM/I rain rates to hurricane analysis and forecasting", *ISPRS J. Photogram. Remote Sens.*, Vol. 59, pp. 233-243, 2005.
2. S. H. Chen, "The Impact of Assimilating SSM/I and QuikSCAT Satellite Winds on Hurricane Isidore Simulations", *Journal of Monthly Weather Review*, Vol. 135, pp. 549-566, Feb. 2007.
3. D. B. Chelton, M. H. Freilich, "On the Use of QuikSCAT Scatterometer Measurements of Surface Winds for Marine Weather Prediction", *Journal of Monthly Weather Review*, Vol. 134, pp. 2055-2071, Aug. 2006.
4. P. S. Chang, Z. Jelenak, J. M. Sienkiewicz, R. Knabb, M. J. Brennan, D. G. Long, and M. Freeberg, "Operational Use and Impact of Satellite Remotely Sensed Ocean Surface Vector Winds in the Marine Warning and Forecasting Environment", *Oceanography*, Vol. 22, No. 2, pp. 194-207, 2009.
5. M. J. Brennan, C. C. Hennon, R. D. Knabb, "The Operational Use of QuikSCAT Ocean Surface Vector Winds at the National Hurricane Center", *Journal of Weather and Forecasting*, Vol. 24, pp. 621-645, June 2009.
6. W. L. Jones, et al., "The SeaSat-A Satellite Scatterometer: The Geophysical Evaluation of Remotely Sensed Wind Vectors Over the Ocean", *Journal of Geophysical Research*, Vol. 87, pp. 3297-3317, 1982.
7. F. M. Naderi, et al., "Space Borne Radar Measurement of Wind Velocity Over the Ocean – an Overview of the NSCAT Scatterometer System", *IEEE Proceedings*, Vol. 79, pp. 850-866, 1991.
8. D. Esteban-Fernandez, J. R. Carswell, S. Frasier, P. S. Chang, P. G. Black, F. D. Marks, "Dual-polarized C- and Ku-band Ocean Backscatter Response to Hurricane-Force Winds", *Journal of Geophysical Research*, Vol. 111, pp. 17, 2006.
9. Z. Jelenak and P. S. Chang, "Impact of the Dual-Frequency Scatterometer on NOAA Operations", *International Geoscience and Remote Sensing Symposium (IGARSS), IEEE Conference*, pp. 1808-1811, 25-30 July, 2010.
10. Z. Jelenak and P. S. Chang, et al., "Dual Frequency Scatterometer (DFS) on GCOM-W2 Satellite: Instrument Design, Expected Performance and User Impact", March 2009.

11. M. W. Spencer, et al., "Improved Resolution Backscatter Measurements with the Sea Winds pencil-beam Scatterometer", *IEEE Trans. Geoscience and Remote Sensing*, Vol. 38, pp. 89-104, 2000.
12. W. C. Skamarock, J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G. Duda, X. Yu Huang, W. Wang, J. G. Powers, "A Description of the Advanced Research WRF Version 3", *National Center for Atmospheric Research*, Boulder, Colorado, USA, June 2008.
13. C. Davis, W. Wang, S. S. Chen, Y. S. Chen, K. Corbosiero, "Prediction of Land falling Hurricanes with the Advanced Hurricane WRF Model", *Journal of Monthly Weather Review*, Vol. 136, pp. 1990-2005, June 2008.
14. S. O. Alsheiss, P. Laupattarakasem, W. L. Jones, "A Novel Ku-Band Radiometer/Scatterometer Approach for Improved Oceanic Wind Vector Measurements", *IEEE Trans. on Geoscience and Remote Sensing*, Vol. 49, Issue 9, pp. 3189-3197, Sept. 2011.
15. R. Gaston and E. Rodriguez, "QuikSCAT Follow-On Concept Study", *National Aeronautics and Space Administration (NASA), JPL Publication 08-18*, Pasadena, California, April 2008.
16. R. Mendelsohn, K. Emanuel, S. Chonabayashi, "The Impact of Climate Change on Global Tropical Storm Damages", *The World Bank Finance Economics and Urban Department*, Feb. 2011.